

STAR Upgrades and Plans

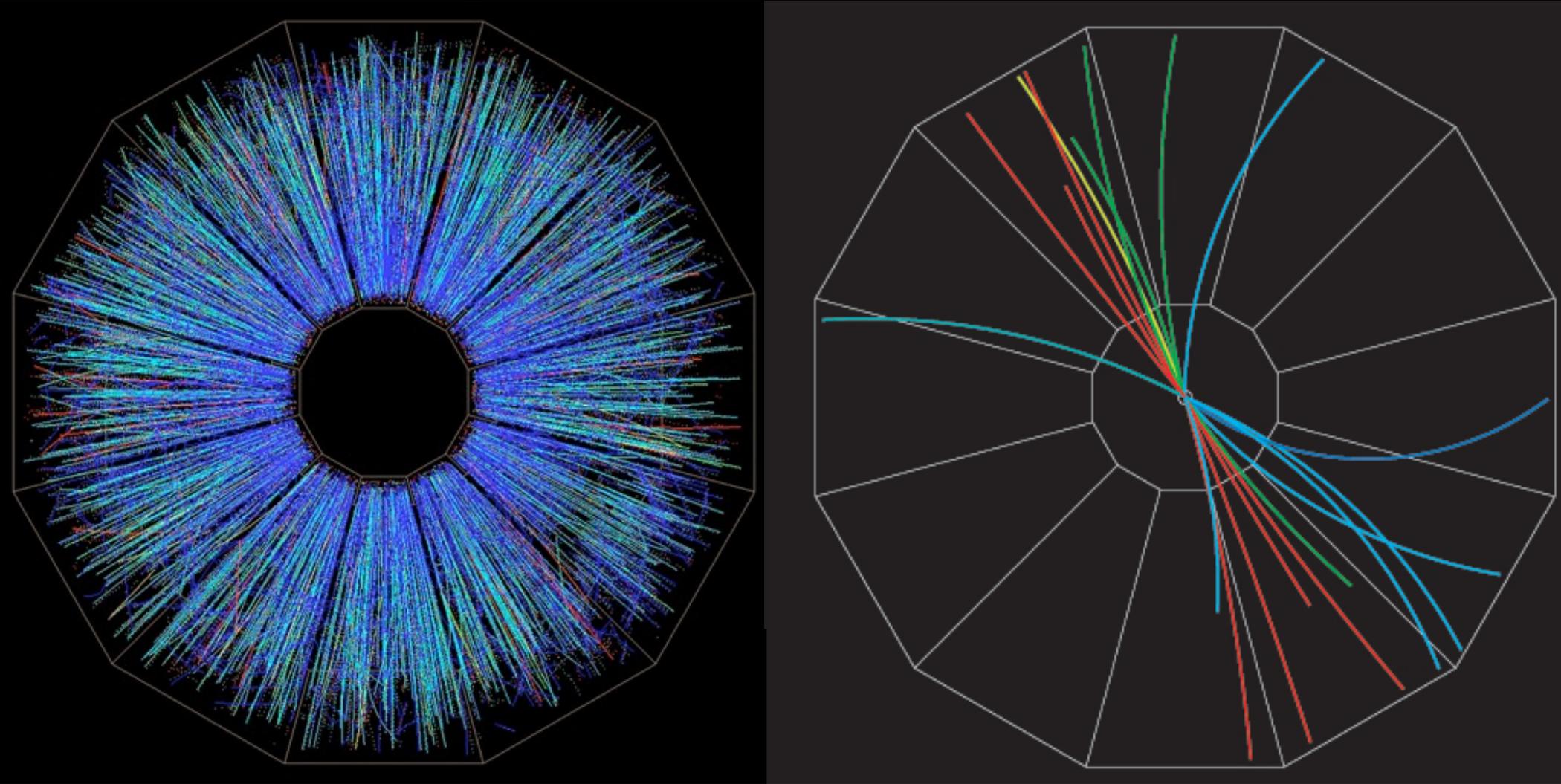
*Ernst Sichtermann, LBNL
for the STAR Collaboration*



2015 RHIC & AGS Annual Users' Meeting
BNL, June 11, 2015



Solenoidal Tracker At RHIC



A versatile instrument to study QCD: A+A, p+A, p+p, $\sqrt{s} = 7.7 - 510$ GeV, polarization.

EEMC

Magnet

MTD

BEMC

TPC

TOF

BBC

Heavy Flavor Tracker

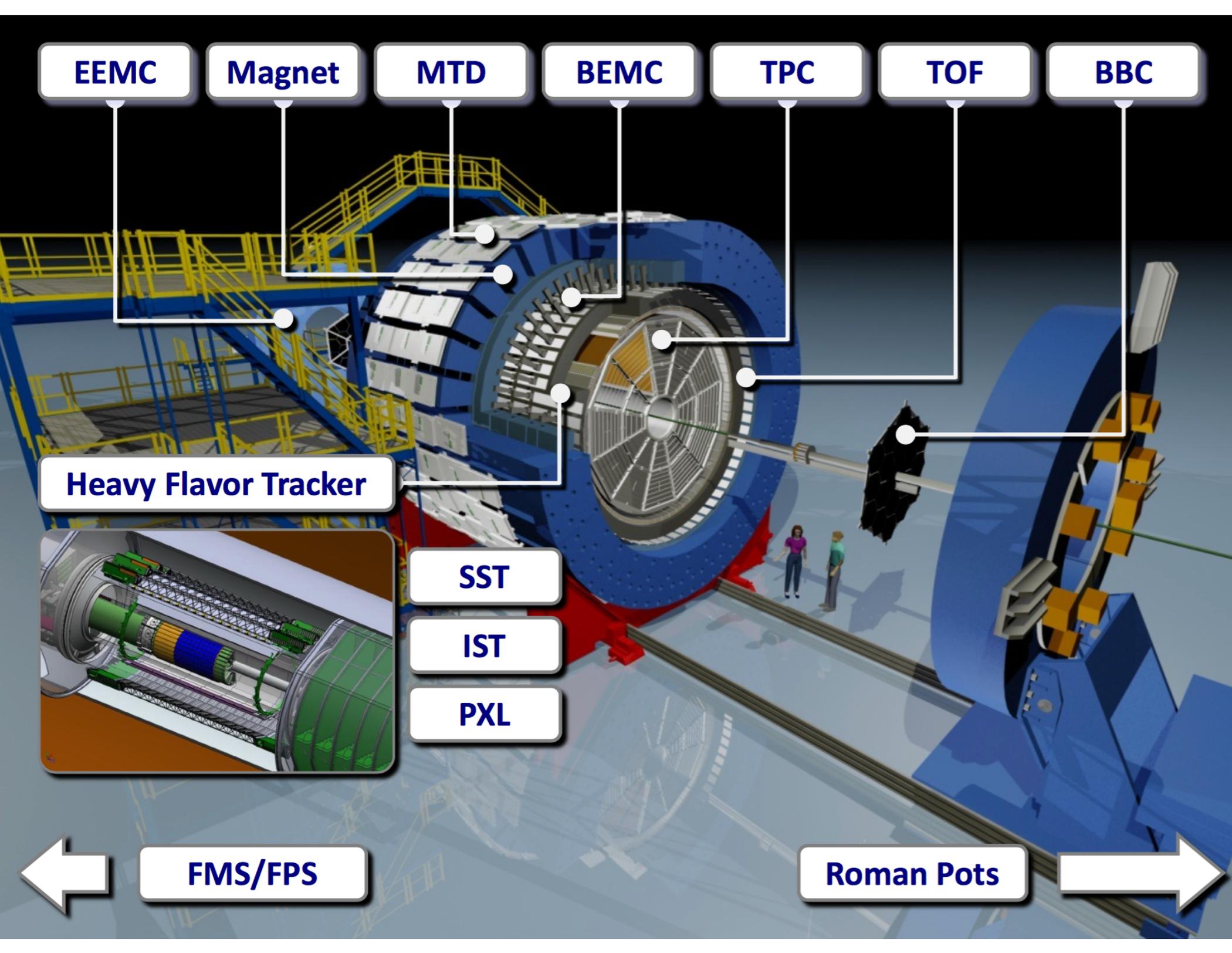
SST

IST

PXL

FMS/FPS

Roman Pots



EEMC

Magnet

MTD

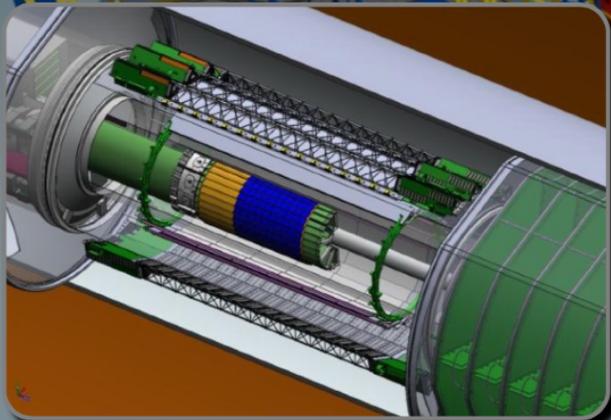
BEMC

TPC

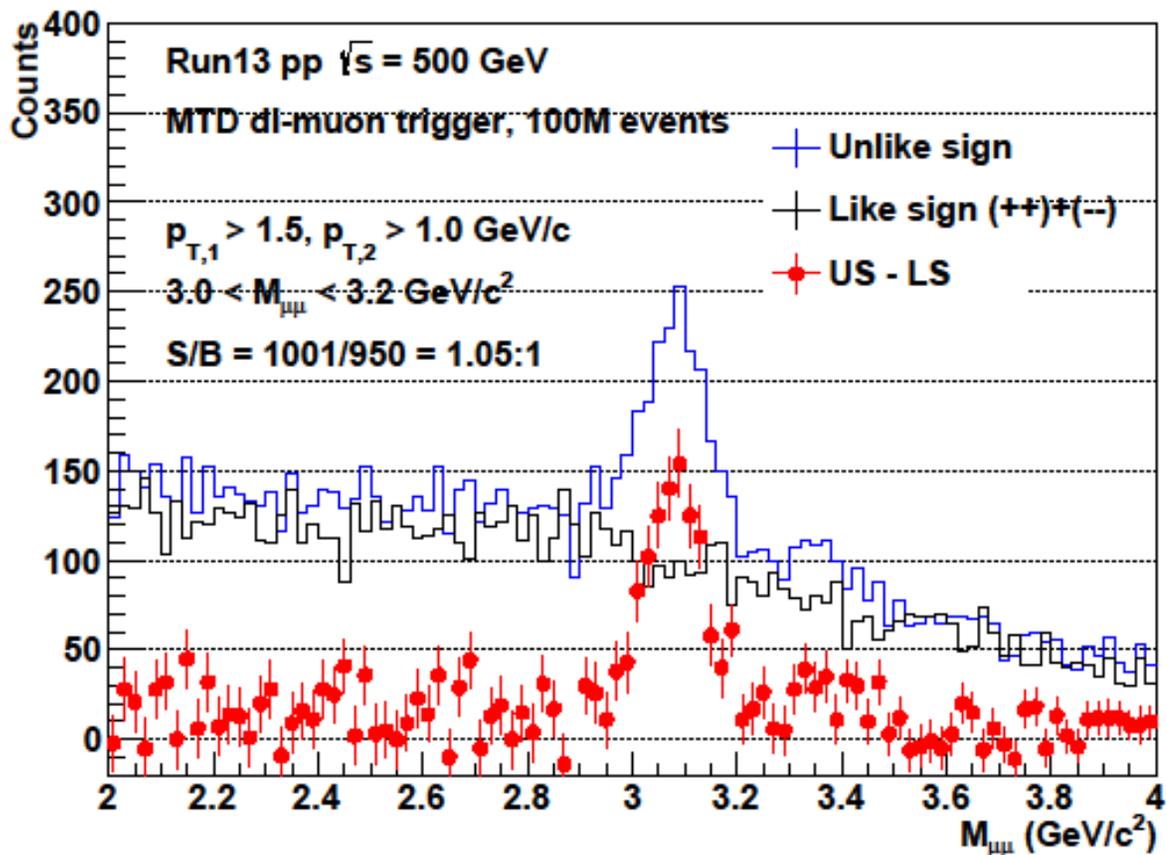
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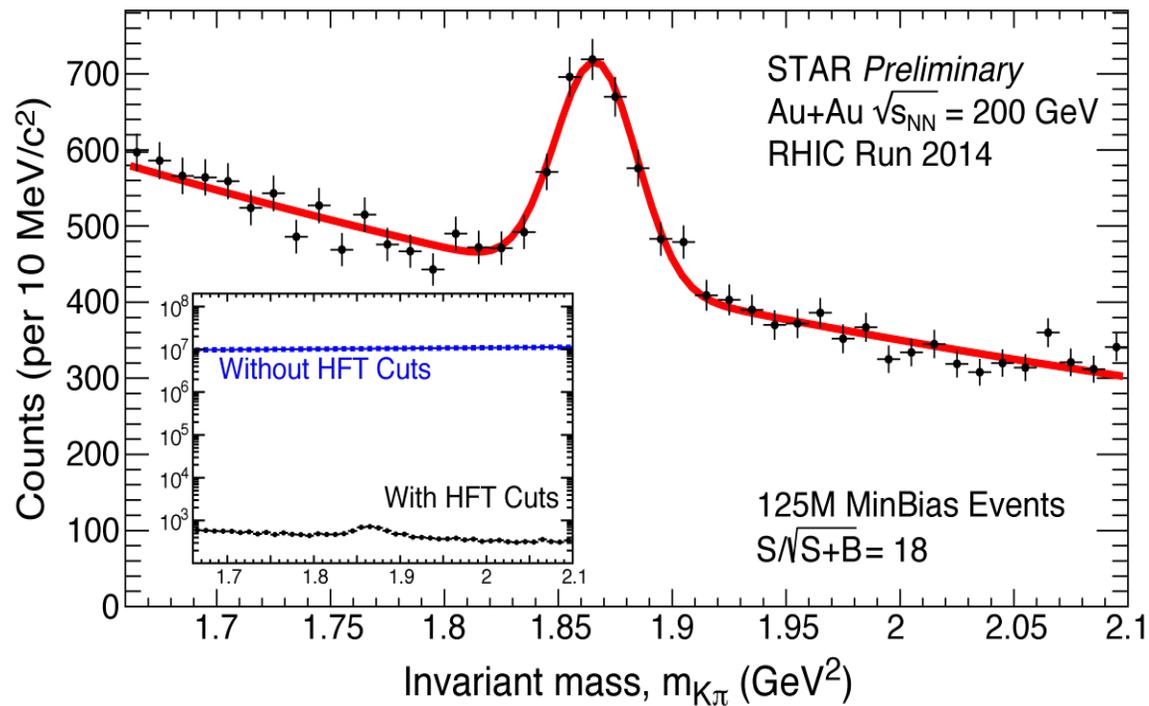
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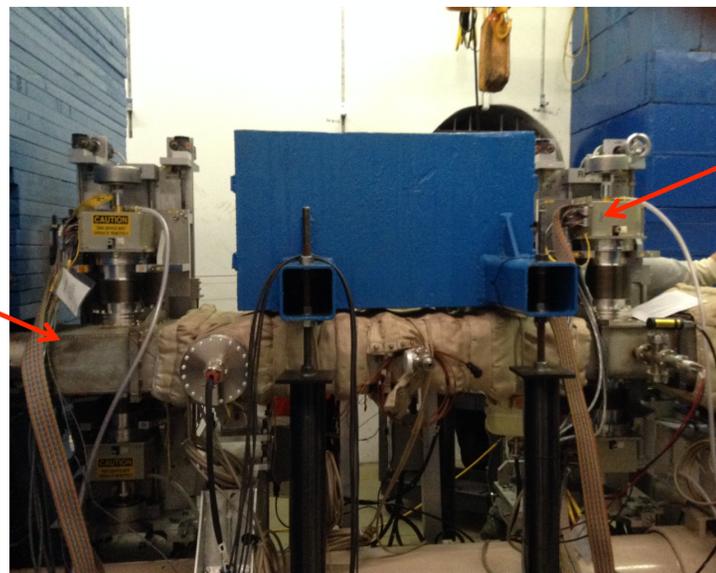
BBC

See Oleg Eyser's STAR run-15 report:
- Heavy Flavor reference data on tape
- New capabilities with FMS/FPS,
Roman Pots



New DX-D0 Chamber

Roman Pot



FMS/FPS

Roman Pots

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Heavy Flavor Tracker

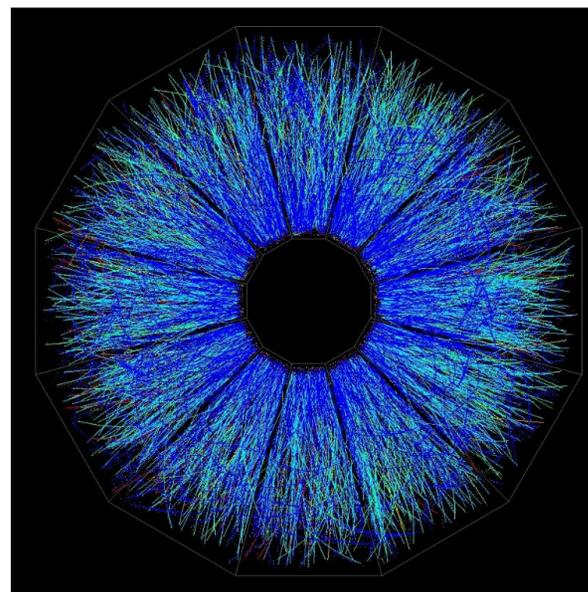
SST

IST

PXL

RHIC Beam Use Request For Runs 16 and 17

The STAR Collaboration



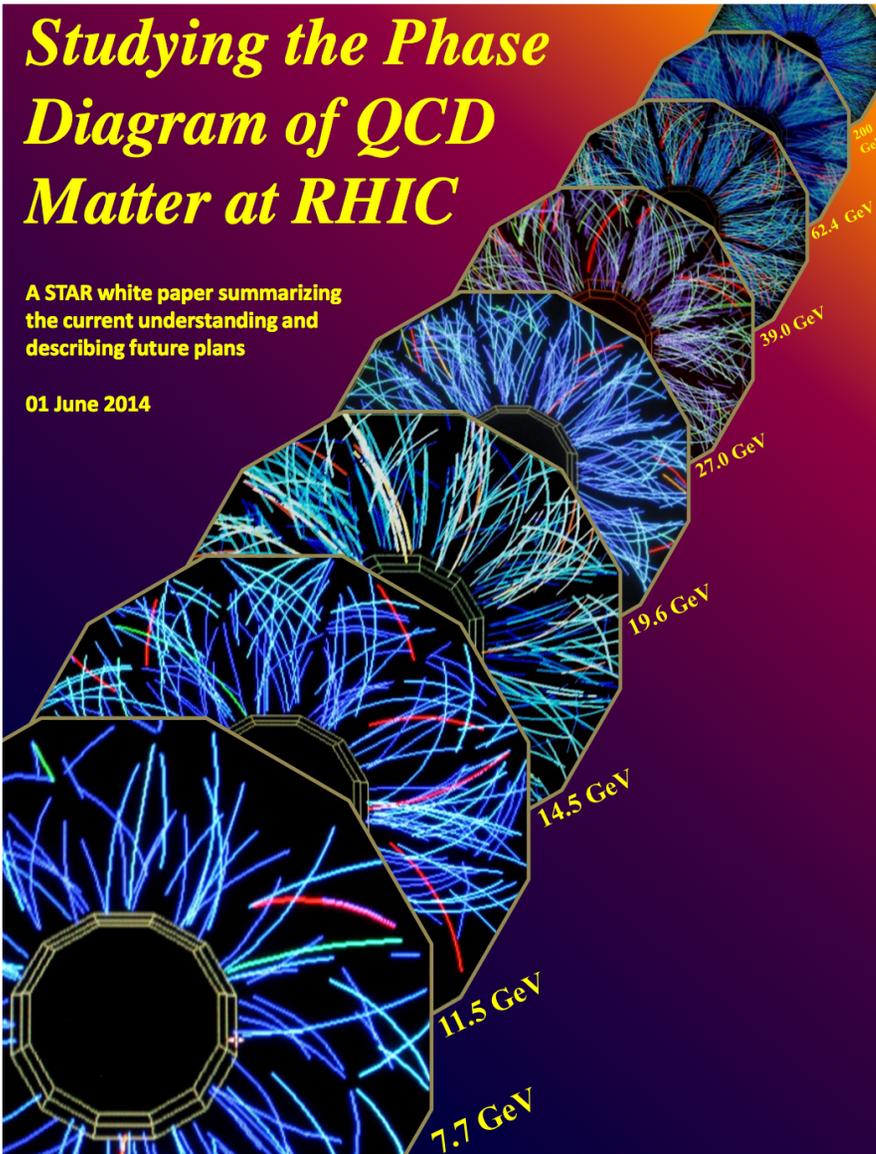
May 19, 2015

FMS/FPS

/ tailcatcher

Roman Pots

Looking beyond Run-17: Beam-Energy Scan Phase-II, iTPC

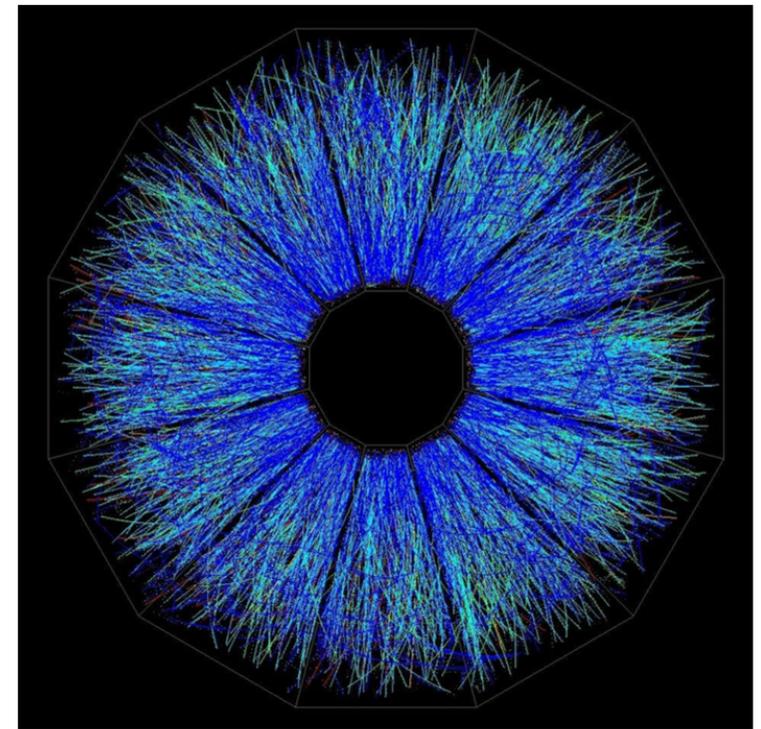


<http://drupal.star.bnl.gov/STAR/starnotes/public/sn0598>

A Proposal for STAR Inner TPC Sector Upgrade (iTPC)

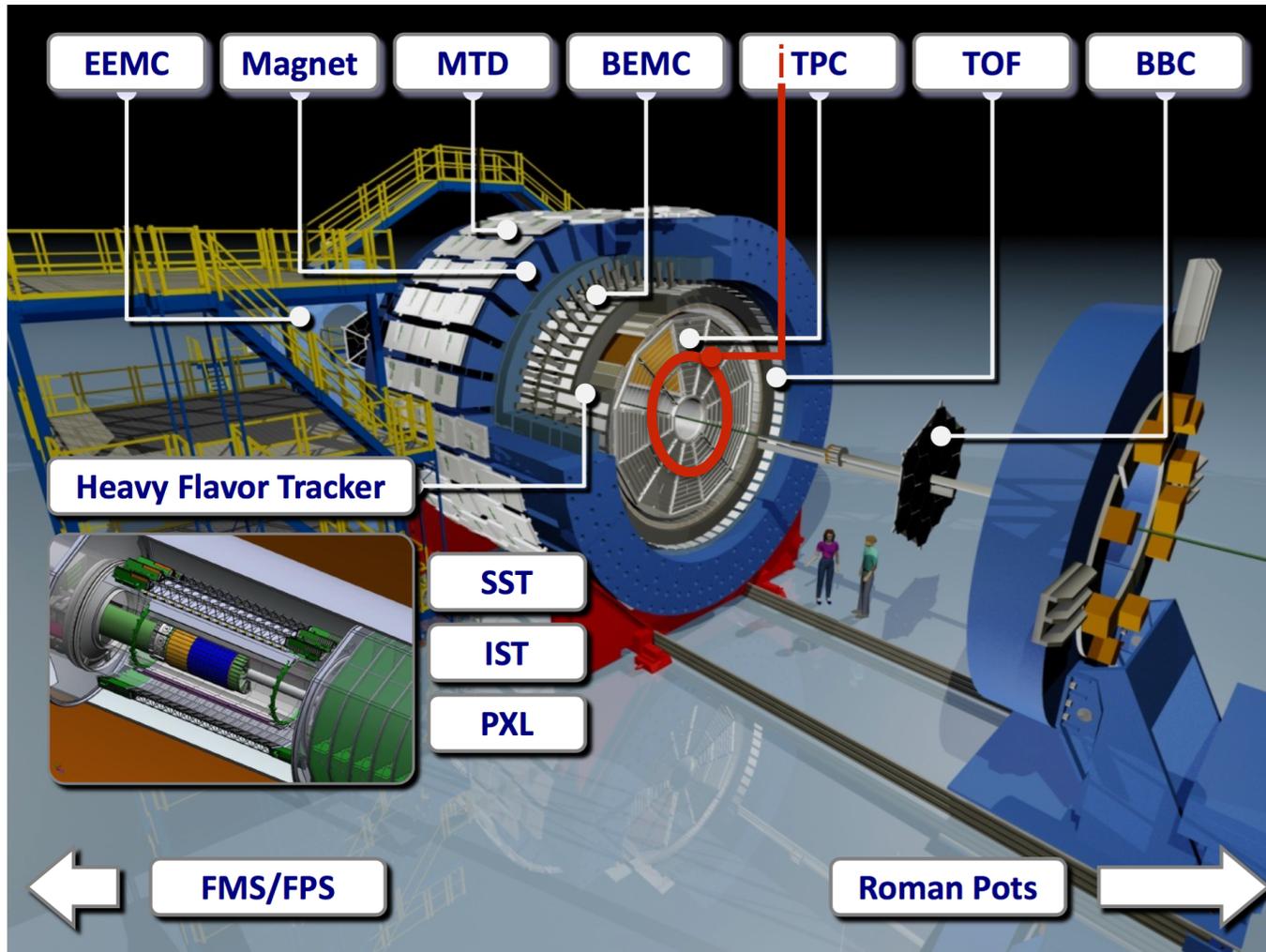
The STAR Collaboration

June 9th, 2015



Part of the NPP-PAC agenda next week

iTPC



Proposal to upgrade the 24 inner TPC sectors to:

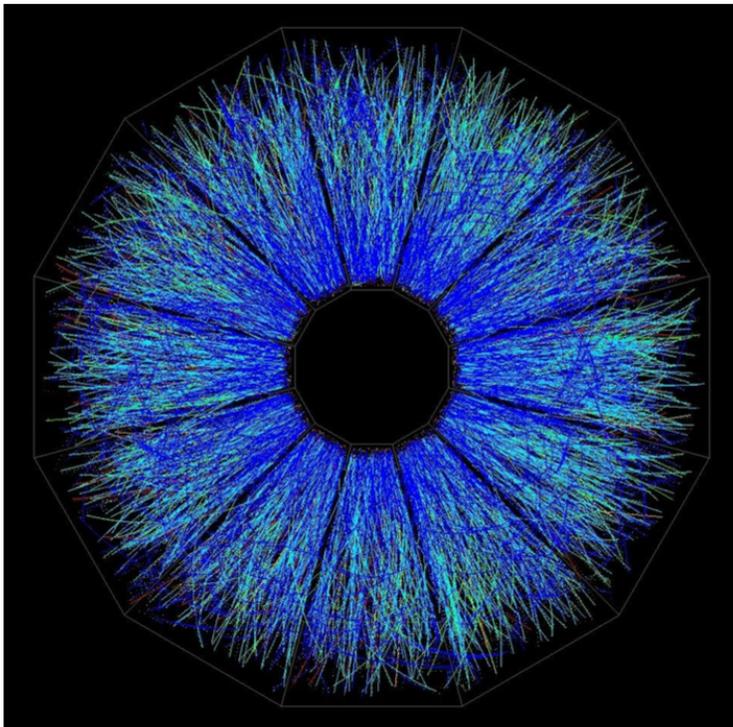
- increase the segmentation on the pad planes,
- renew inner sector wires.

iTPC

A Proposal for STAR Inner TPC Sector Upgrade (iTPC)

The STAR Collaboration

June 9th, 2015



Key project components:

- MWPC and pad-plane,
- Strongback,
- Electronics and DAQ,
- Sector insertion tool.

Participating institutions:

BNL, Czech Tech. U.,
KSU, LBNL, NPI Prague,
Shandong U., SINAP,
U.C. Davis, UT Austin,
USTC.

Instal and test prior to start
of BES-II in Jan. 2019 (as-
sumes funding, RHIC-plan).

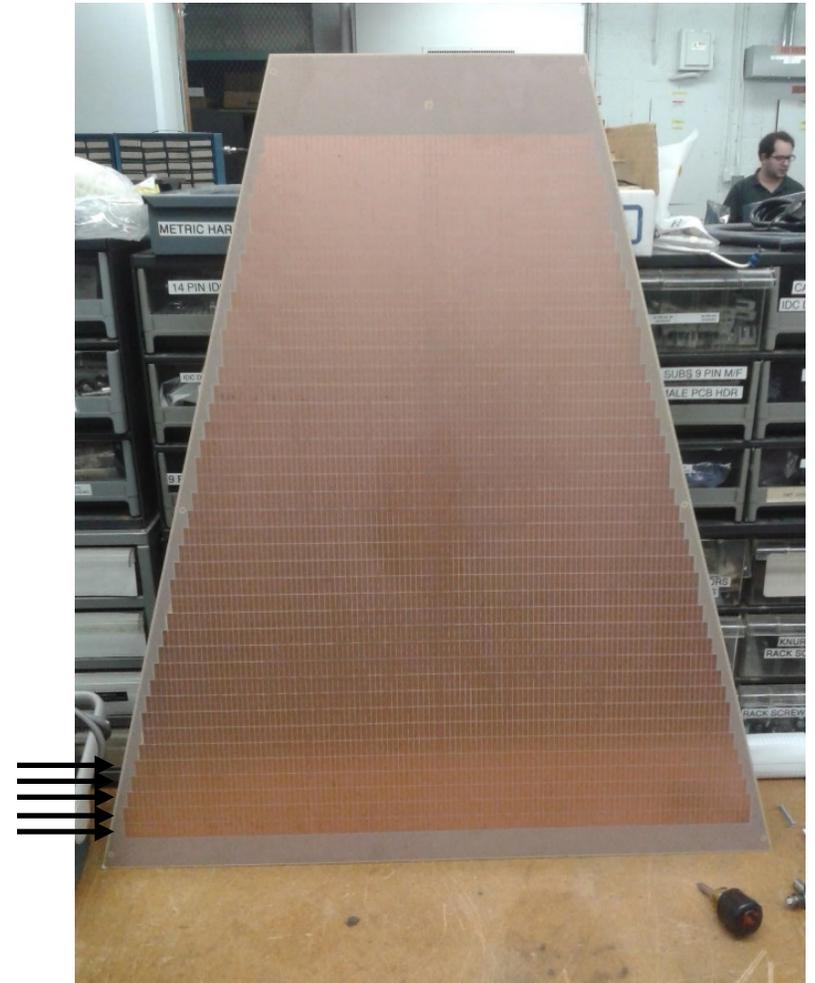
iTPC

Existing (spare) inner TPC sector



widely spaced ($> 5\text{cm}$) pad-rows

iTPC prototype pad-plane (tested)



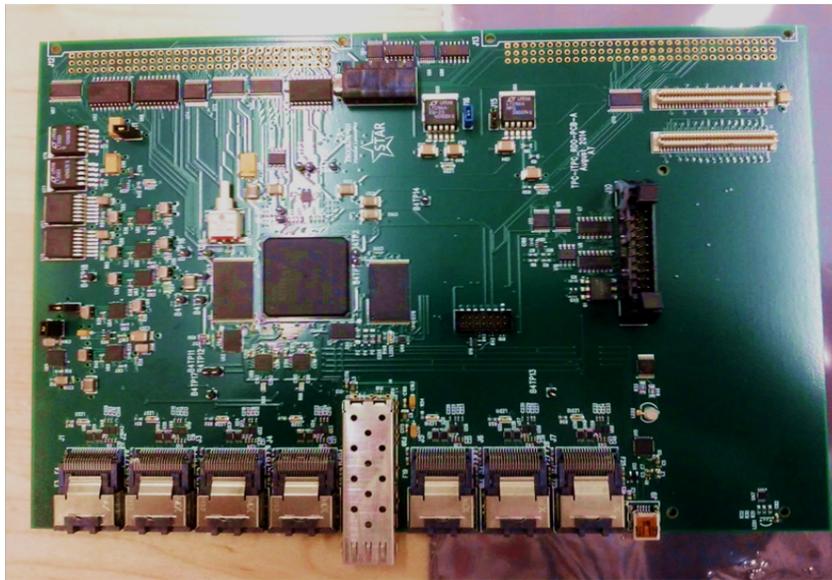
Upgrade is to increase the number of inner readout channels by a factor ~ 2 (optimized), increase the sampled track length to $\sim 95\%$, and thereby improve efficiency, in particular at low p_T improve particle identification via dE/dx , extend analyzed acceptance to larger (absolute) pseudo-rapidities.

iTPC - Electronics

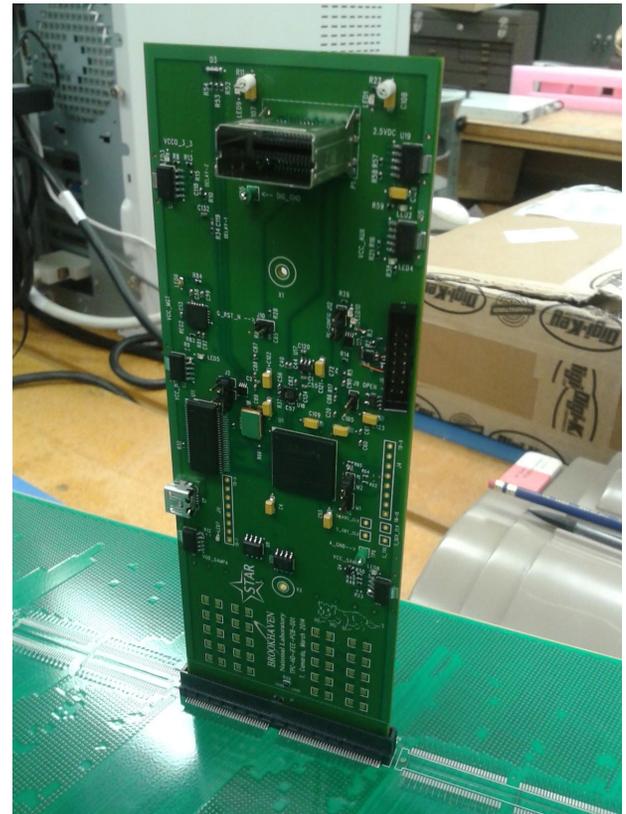
FEE is based on current TPC FEE, but using the ALICE SAMPA chip,

Twice the channels per FEE,

RDO similar to existing TPC RDO.



iTPC RDO prototype



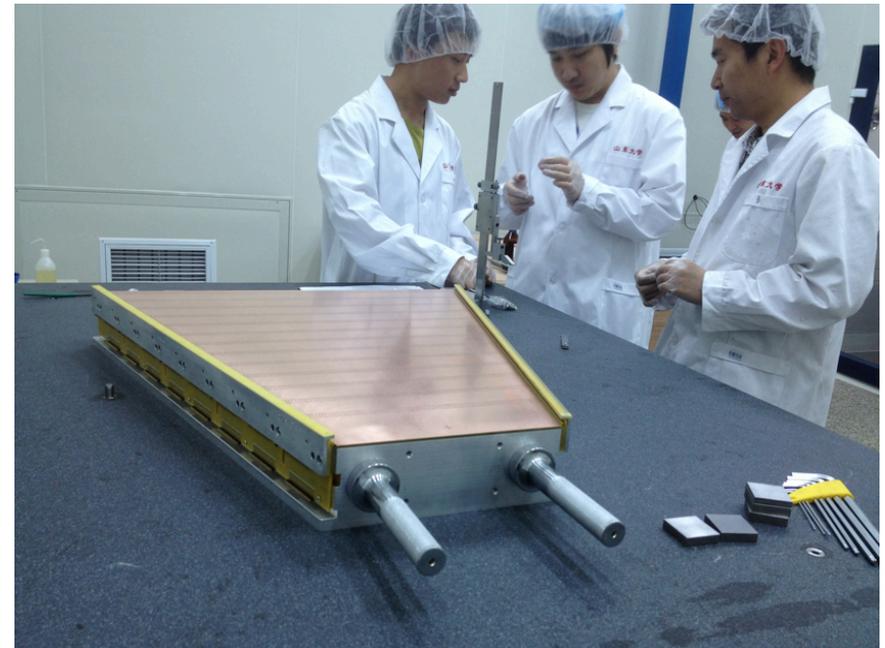
pre-prototype iTPC FEE,
plugged into the pad plane

iTPC - Strongback and Prototyping

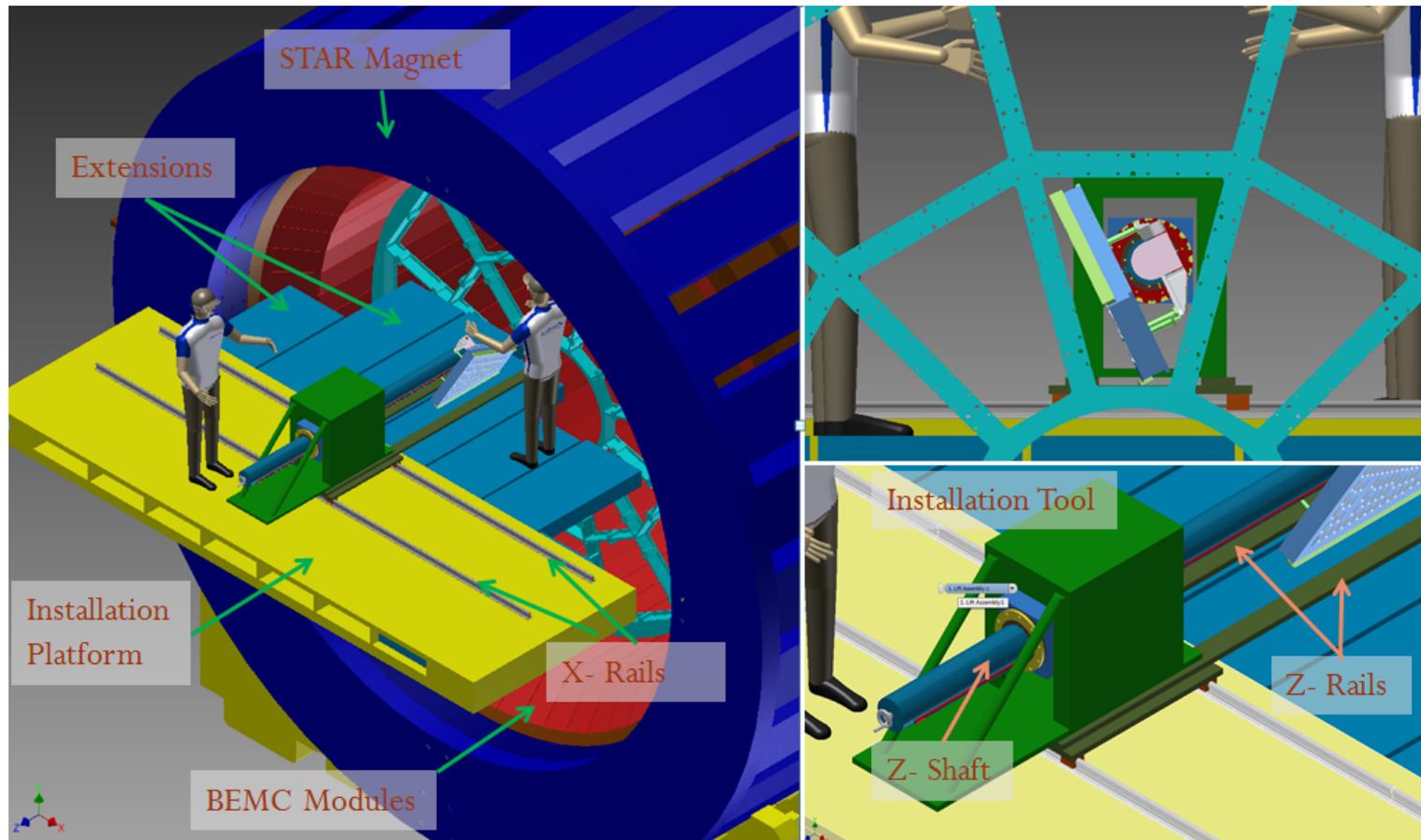


iTPC strongback prototype from original drawings, design will follow TPC design, with adapted positioning of FEE openings no other (re-)design planned.

Test-driving assembly, winding, testing at Shandong U.

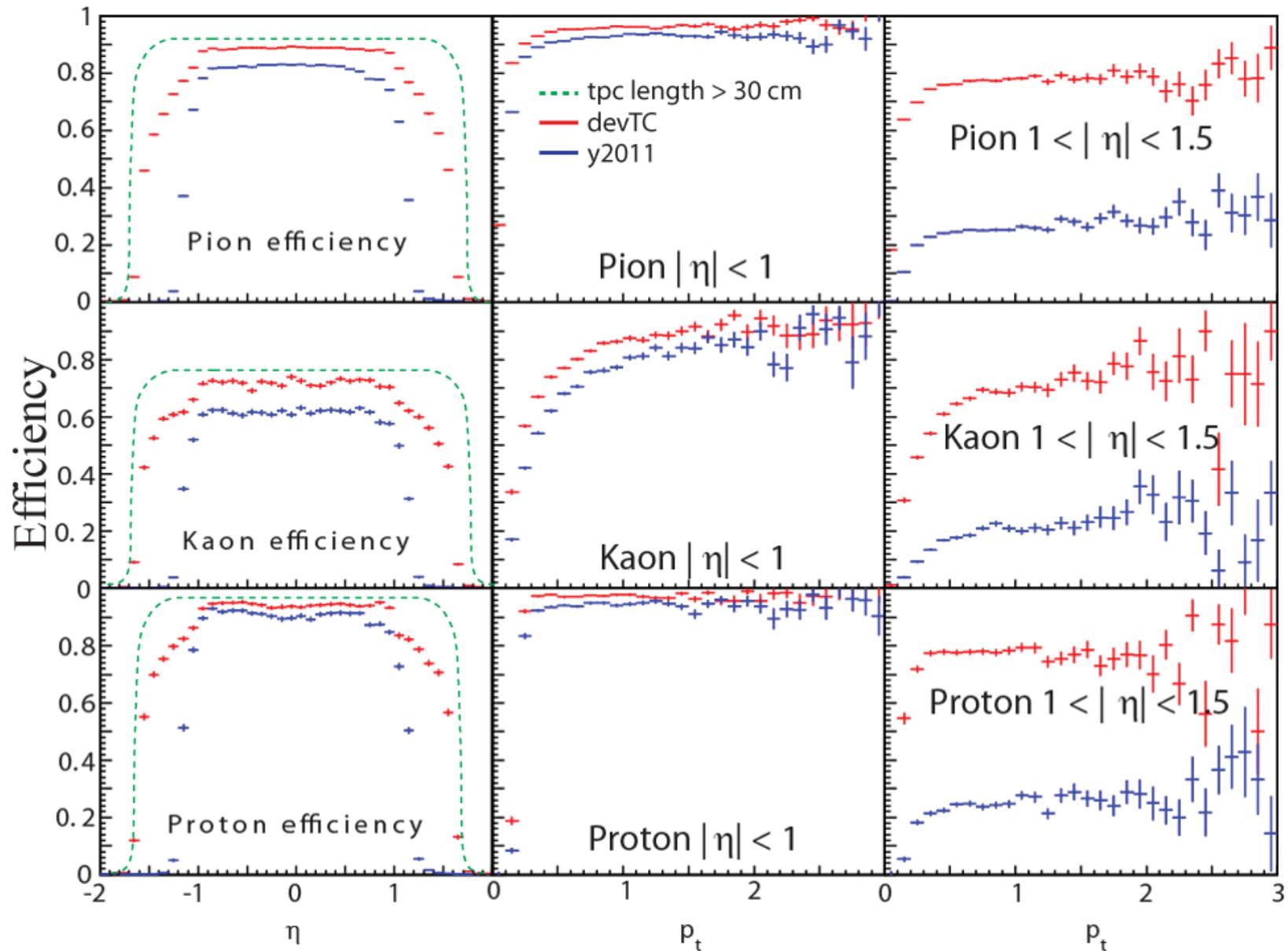


iTPC - Sector Insertion Tool



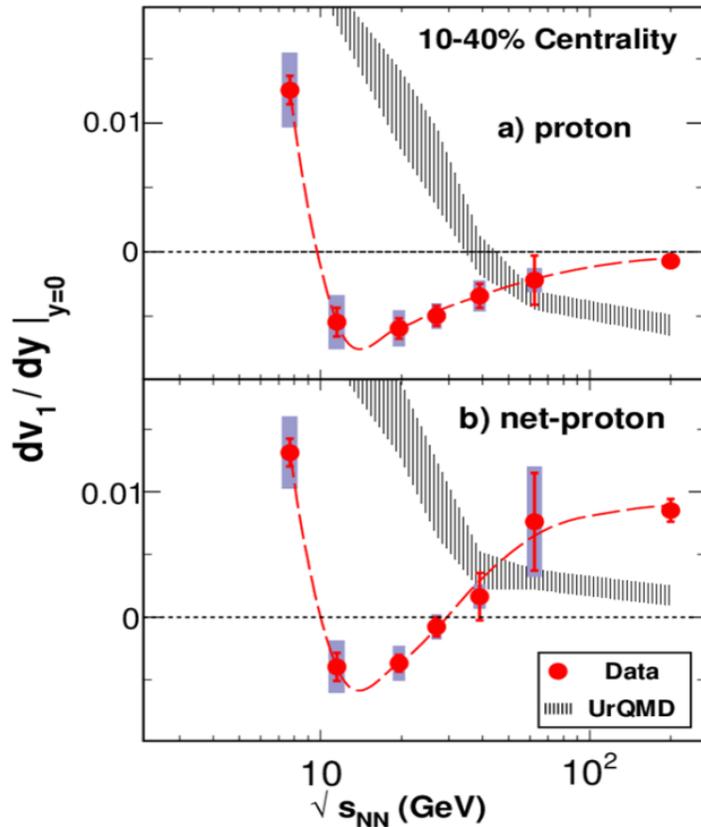
Concept adapted from ALICE design, cartesian coordinates.
Raisable support and safety measures (rails, stairs) not shown here.

iTPC - simulated performance

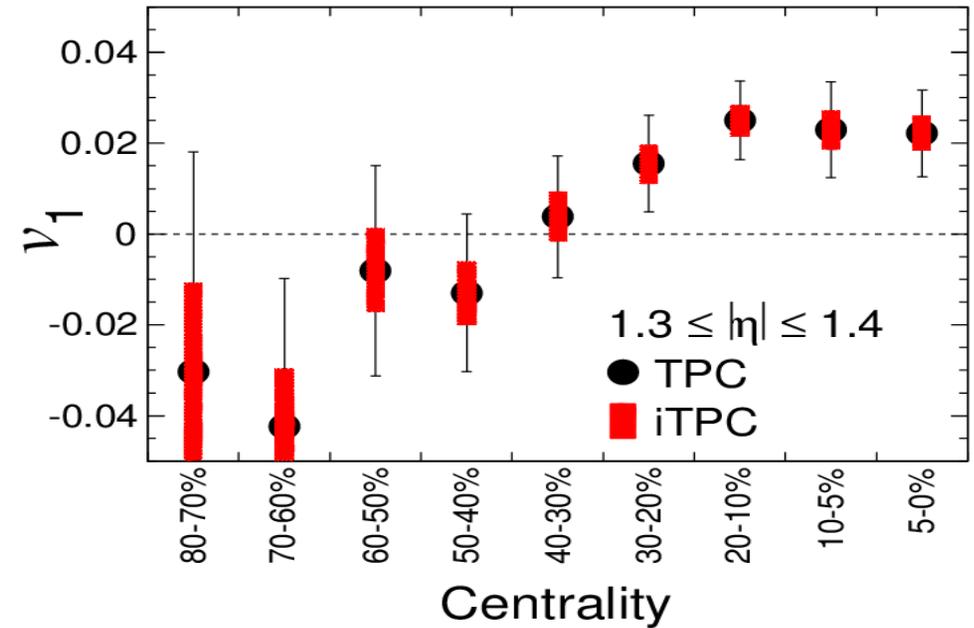


iTPC - a (selected) example of physics impact

Directed flow slope for protons and net-protons near mid-rapidity from BES-I data.



Projected (simulated) 19.6 GeV centrality dependence of directed flow for forward charged-particles with and without iTPC.



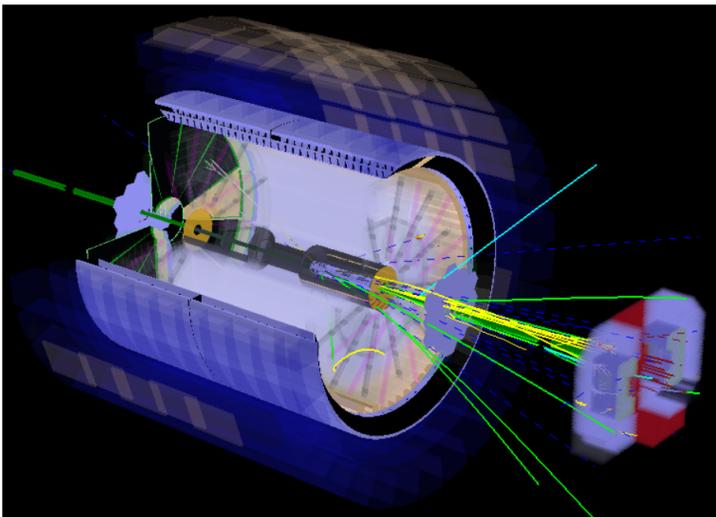
Note: iTPC benefits virtually *all* observables, rapidity coverage for fluctuation analyses, purity for dileptons, proton acceptance for fixed-target, ...

Note: BES-II provides motivation for upgrades besides iTPC: EPD, endcap ToF.

Looking further forward: beyond BES-II *and also before!*

A polarized p+p and p+A program for the next years

The STAR Collaboration



May 2014

Explore QCD at large and small x , driven by four overarching questions:

What is the nature of the spin of the proton?

How do quarks and gluons hadronize into final-state particles?

How can we describe the multidimensional landscape of nucleons and nuclei?

What is the nature of the initial state in nuclear collisions?

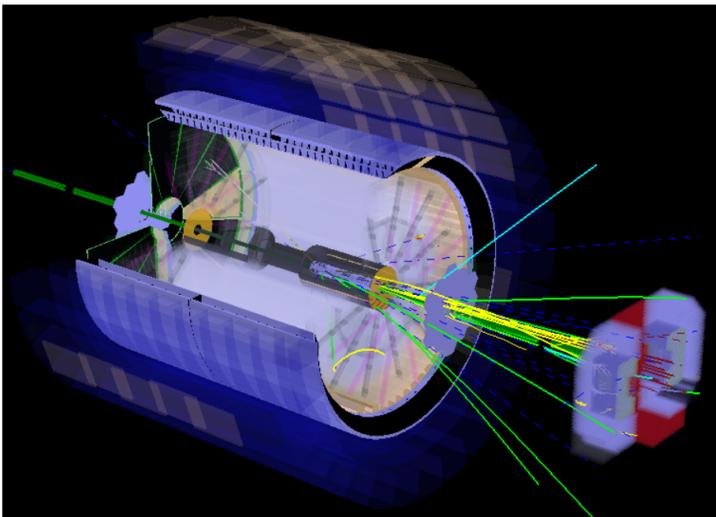
centered around unique RHIC capabilities.

Identifies compelling opportunities with top-energy longitudinally and transversely polarized proton collisions, and transversely polarized p+A (C, Cu, Au) collisions.

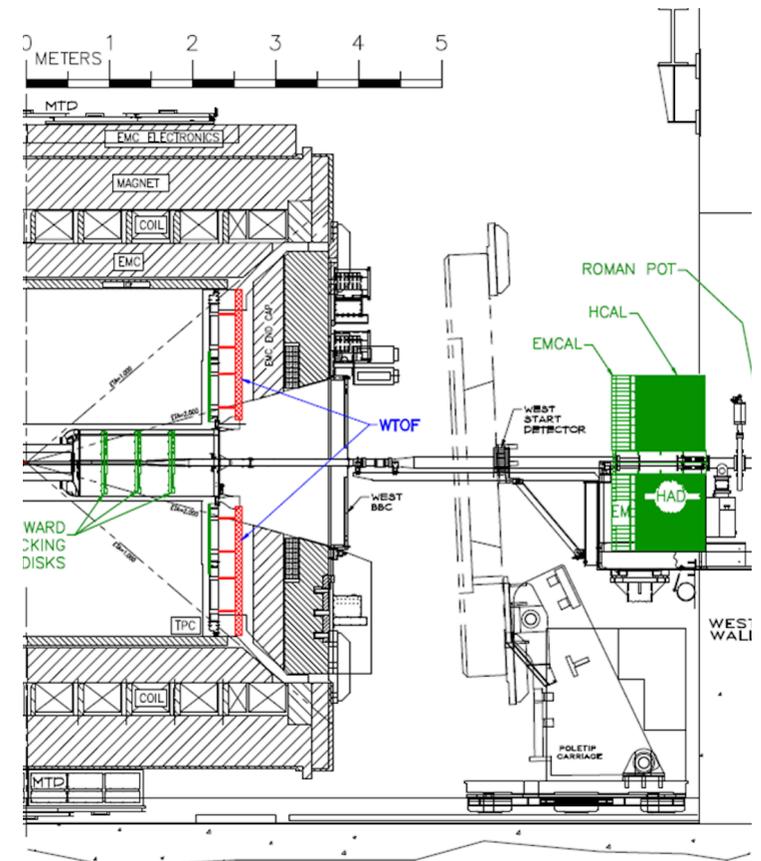
Looking further forward: beyond BES-II *and also before!*

A polarized p+p and p+A program for the next years

The STAR Collaboration



May 2014



Identifies compelling opportunities with top-energy longitudinally and transversely polarized proton collisions, and transversely polarized p+A (C, Cu, Au) collisions.

Motivates *new* forward instrumentation; proposal in preparation.

Looking further forward: beyond BES-II

ECal:

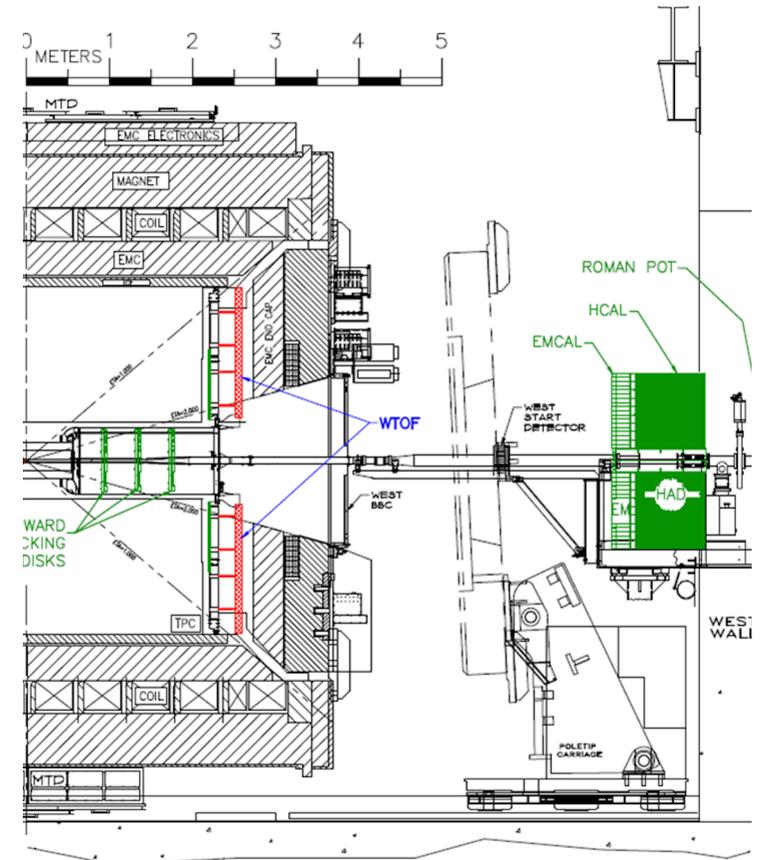
Tungsten-Powder-Scintillating fiber

2.3cm Moliere radius, tower-size $2.5 \times 2.5 \times 17 \text{ cm}^3$

$23 X_0$

HCal:

Lead and Scintillator tiles, tower size $10 \times 10 \times 81 \text{ cm}^3$,
4 interaction lengths



Looking further forward: beyond BES-II

EMCal:

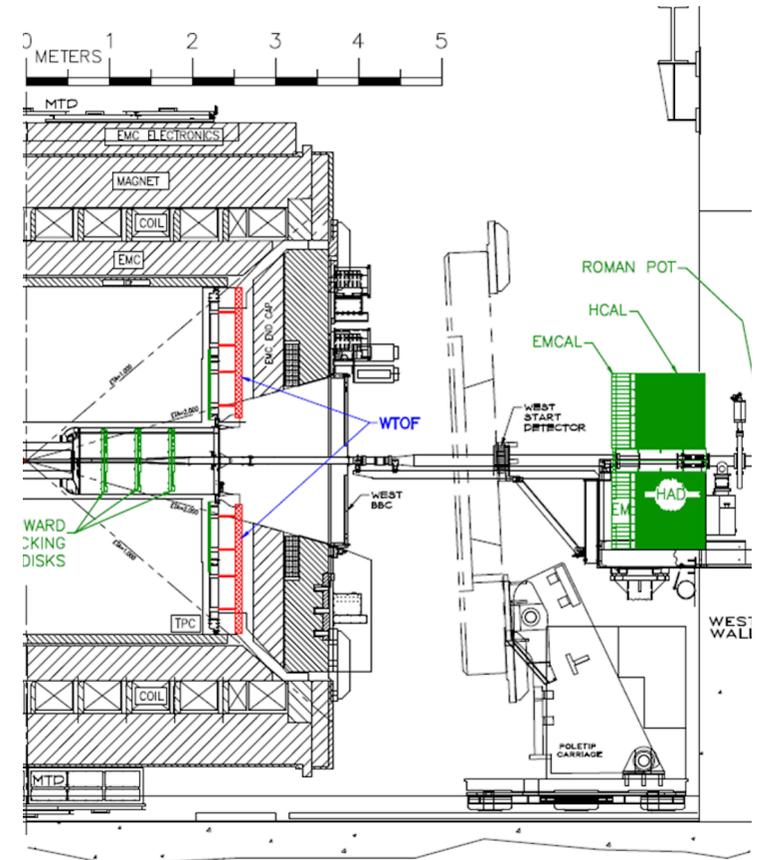
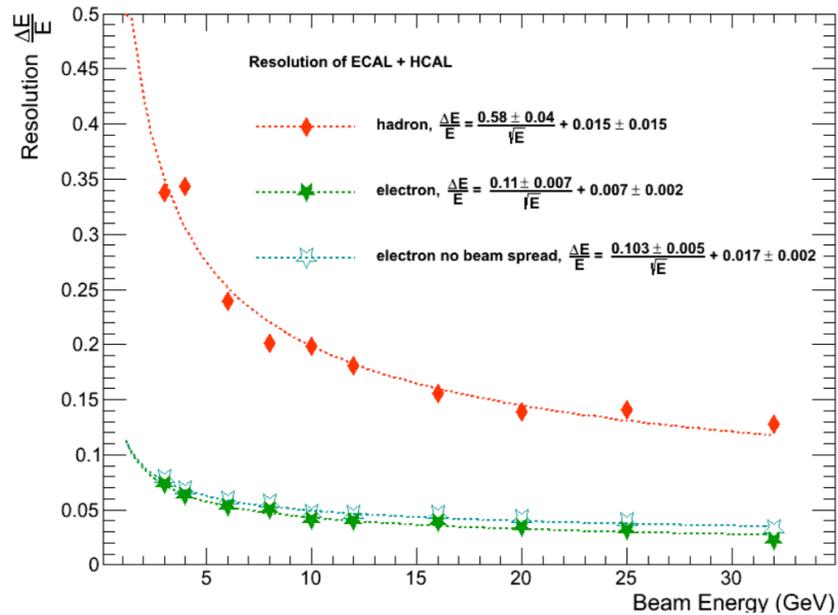
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Looking further forward: beyond BES-II

EMCal:

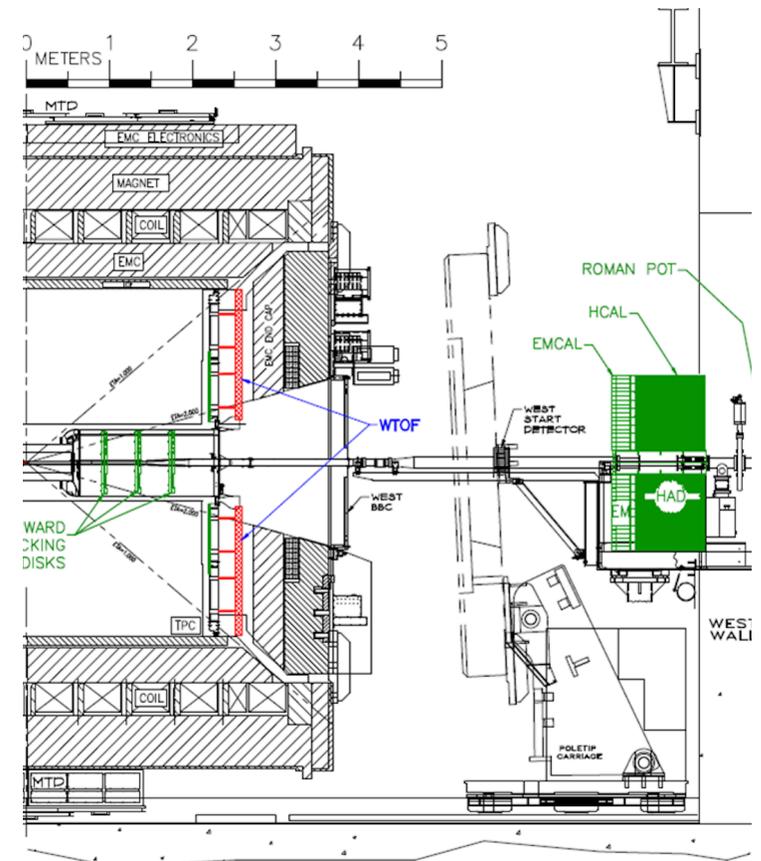
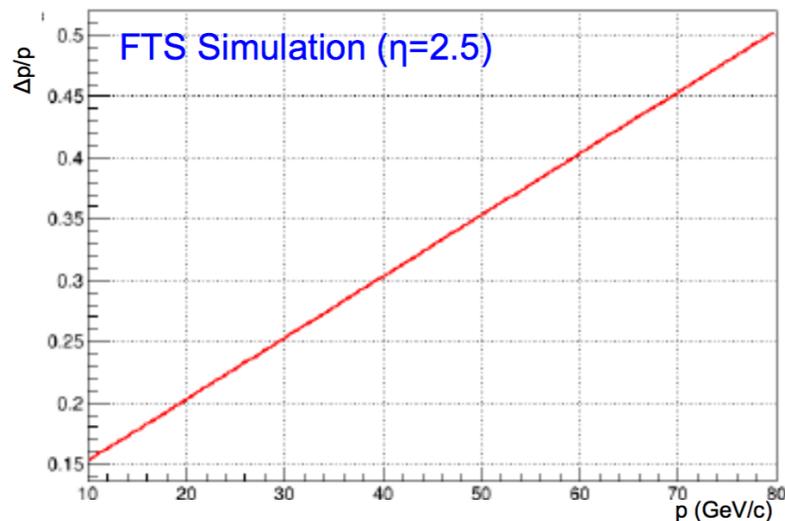
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 $23 X_0$

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Lead and Scintillator tiles, tower size $10 \times 10 \times 81 \text{ cm}^3$,
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Forward Tracking:

Silicon mini-strip detector, full 2π in azimuth and 2.5 - 4 in eta,
< 3% X_0 , < 5% occupancy in central Au+Au,
An alternative, GEM-based, option is also being considered.



Looking further forward: beyond BES-II

EMCal:

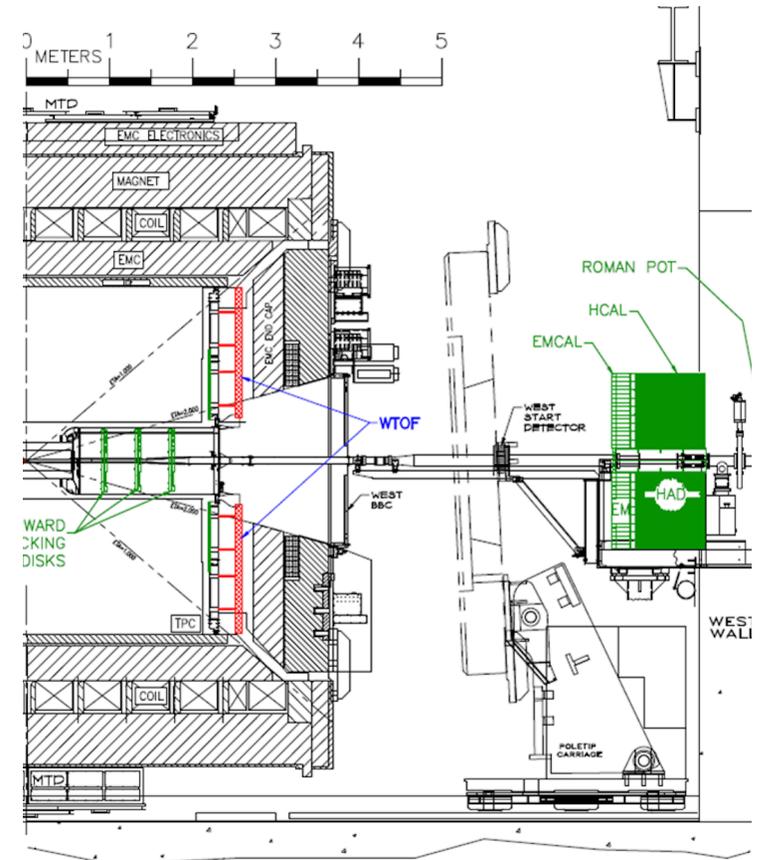
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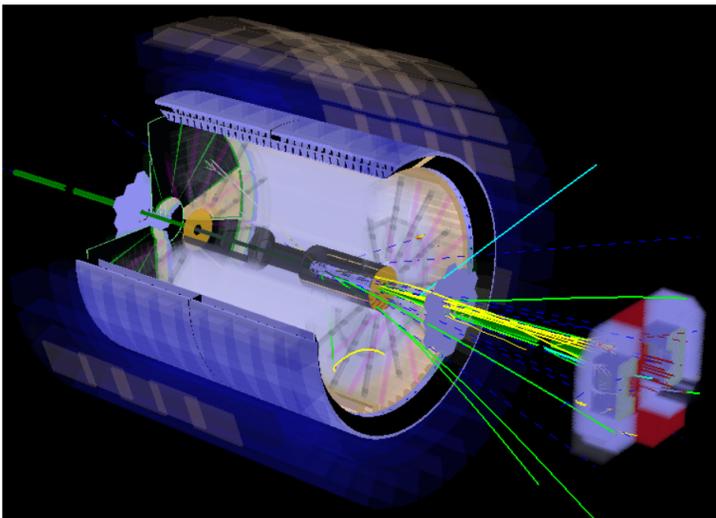
Enables compelling opportunities with top-energy longitudinally and transversely polarized proton collisions, and transversely polarized p+A (C, Cu, Au) collisions.

Proposal in preparation; including emerging A+A science motivations.

Looking further forward: beyond BES-II and also before!

A polarized p+p and p+A program for the next years

The STAR Collaboration



May 2014

<https://drupal.star.bnl.gov/STAR/starnotes/public/sn0605>

Rapid developments since last year,

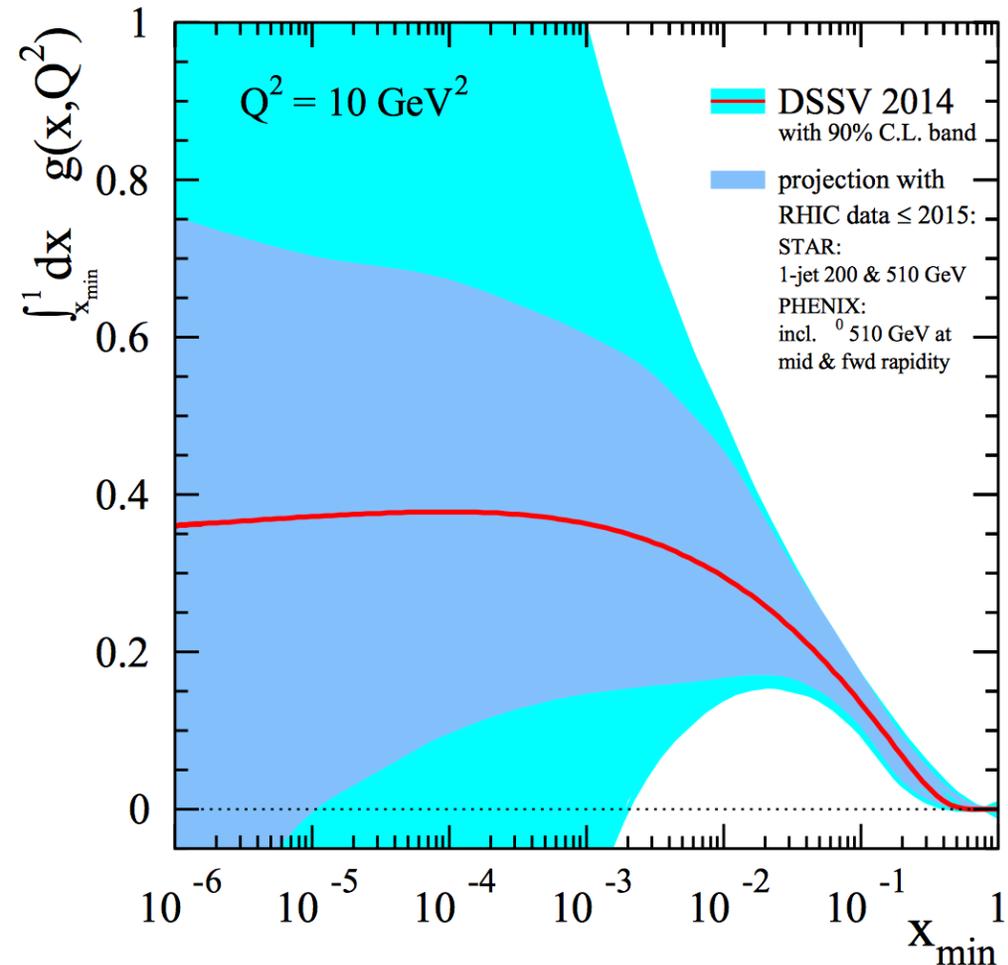
- Run-15 p+Au goals were met earlier than originally anticipated; we are collecting p+Al data since Tuesday.
- A change in the RHIC schedule and new possibility of 15-22 weeks of cryo operations in run-17 makes it possible to address HP13, the Sivers' sign change, with complementary channels at STAR.
- First significant quark transversity signals in p+p, the Collins effect, have now been observed. A future spin-probe of hadronization in the nuclear environment?

See e.g. talks by Mriganka Mondal and Elke Aschenauer past Tuesday at this Mtg.

Looking further forward: after BES-II and prior to EIC

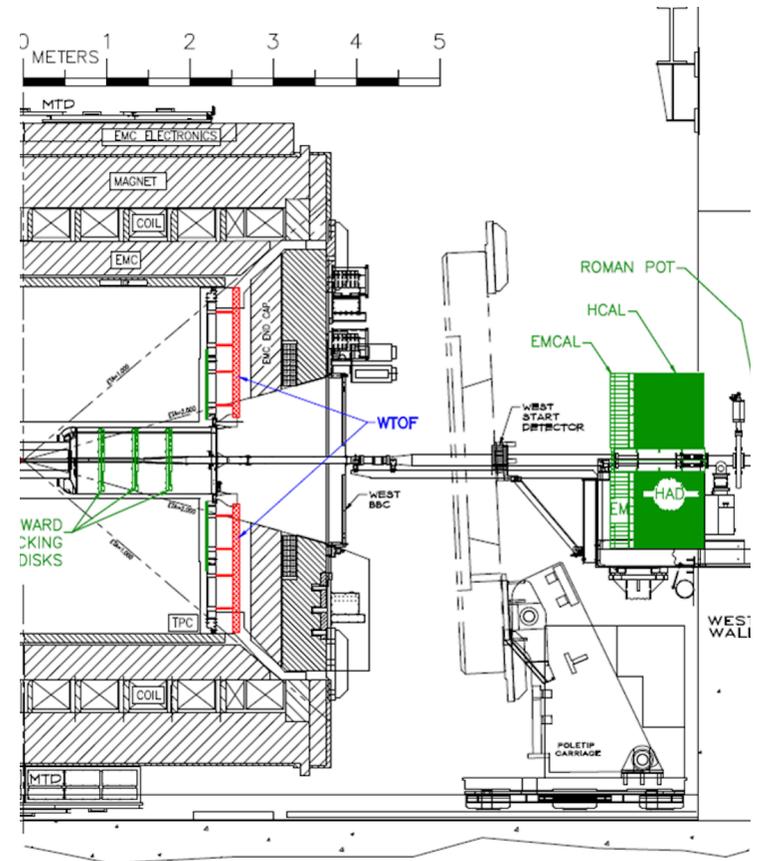
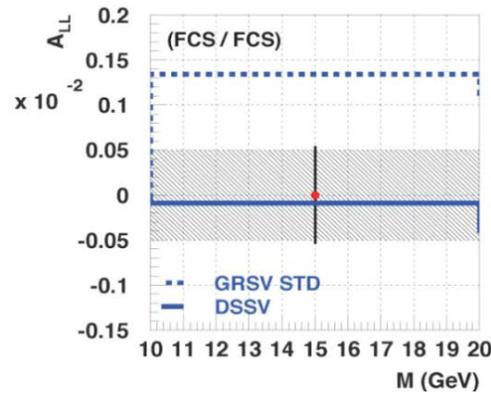
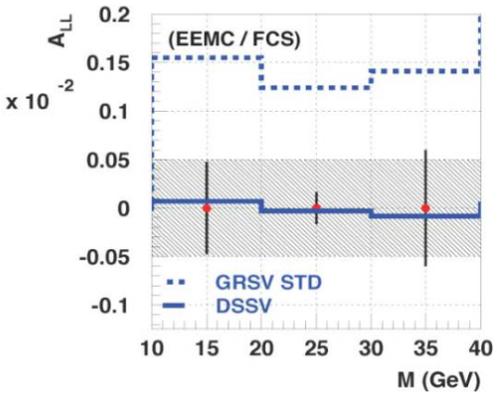
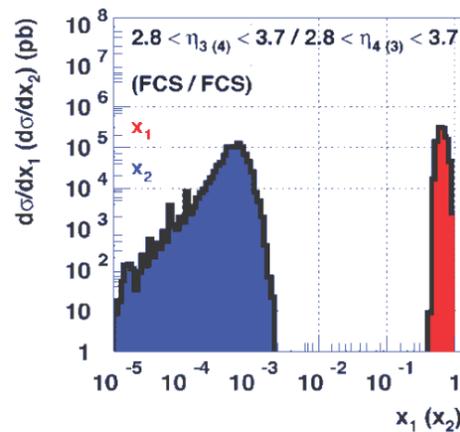
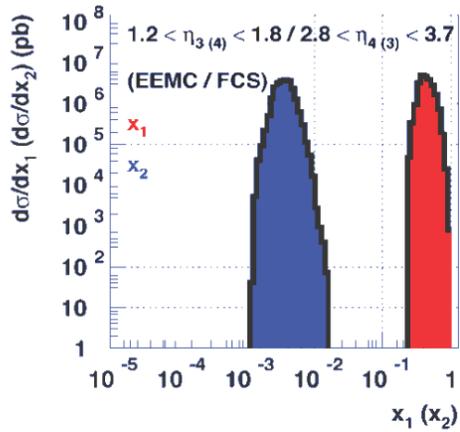
Gluon Polarization:

- Vast progress from RHIC (STAR and PHENIX), but...
- Vast uncertainties will remain at small- x even after run-15,
- Forward instrumentation and longitudinal p+p collisions are the only path forward, prior to EIC; a *high-energy* polarized EIC is the only known path to settle this key question.



Looking further forward: after BES-II and prior to EIC

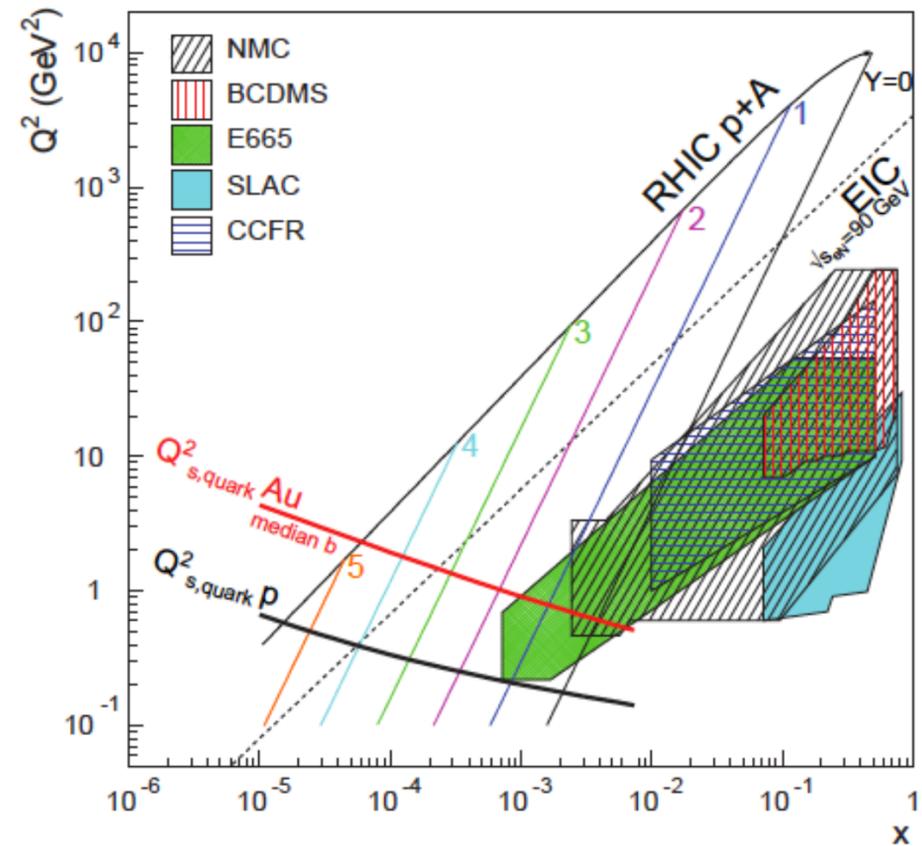
Gluon Polarization - forward di-jets



Looking further forward: after BES-II and prior to EIC

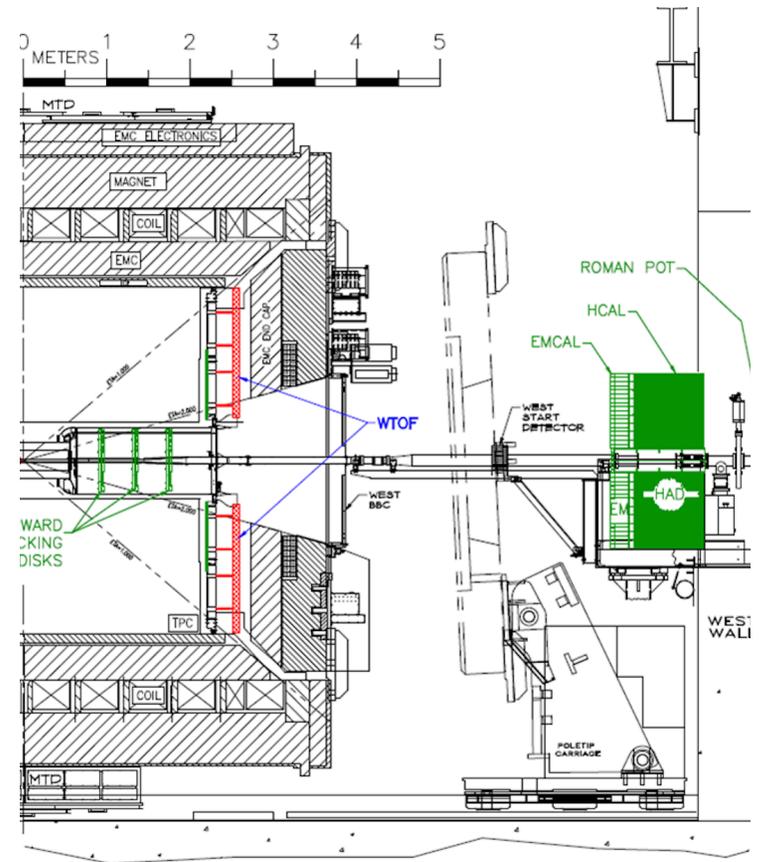
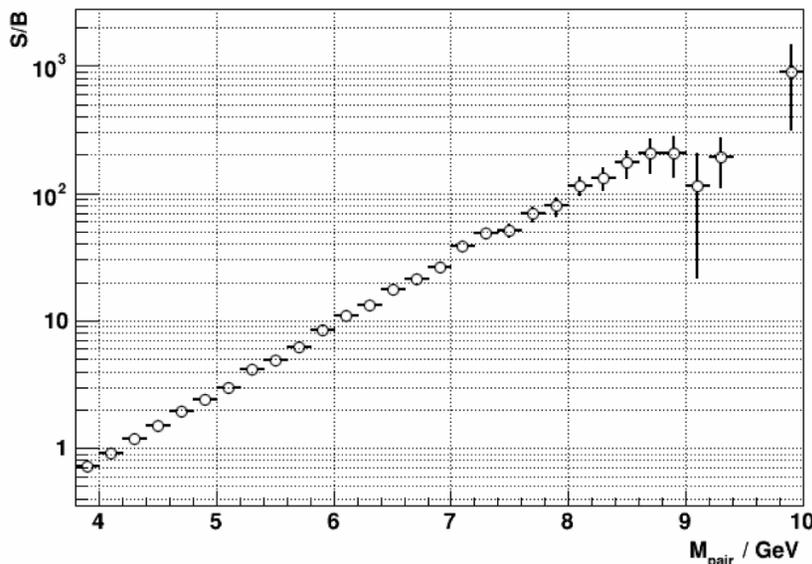
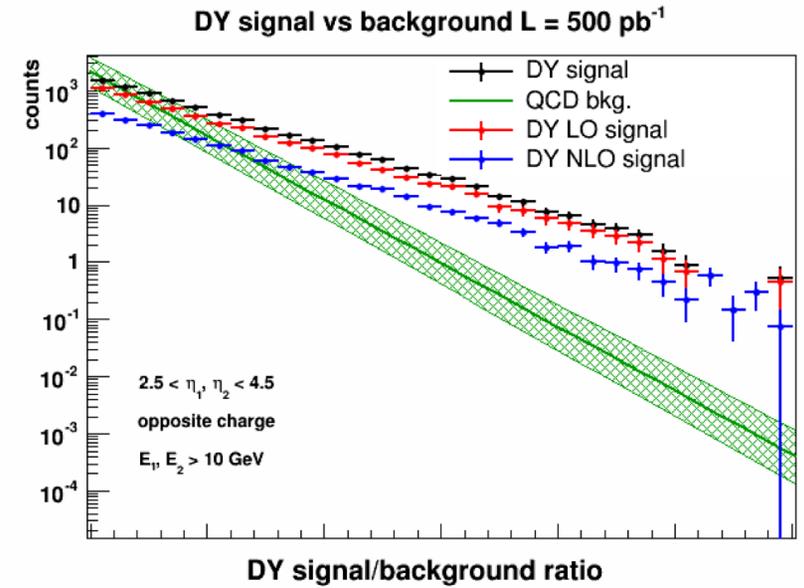
200 GeV Drell-Yan measurements:

- complementary to lepton-nucleon DIS,
- kinematically complete, event-by-event,



Looking further forward: after BES-II and prior to EIC

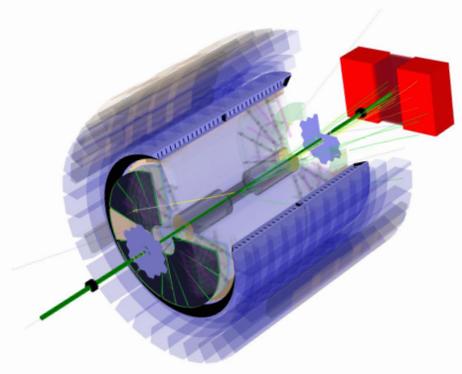
200 GeV Drell-Yan p+p simulated capability:



Note: run-17 proposal has initial STAR DY 510 GeV measurement with existing FMS/FPS and a new tailcatcher as one of its goals.

Transition to eRHIC

<https://drupal.star.bnl.gov/STAR/starnotes/public/sn0592>
eSTAR: A Letter of Intent
 The STAR Collaboration



September 2013

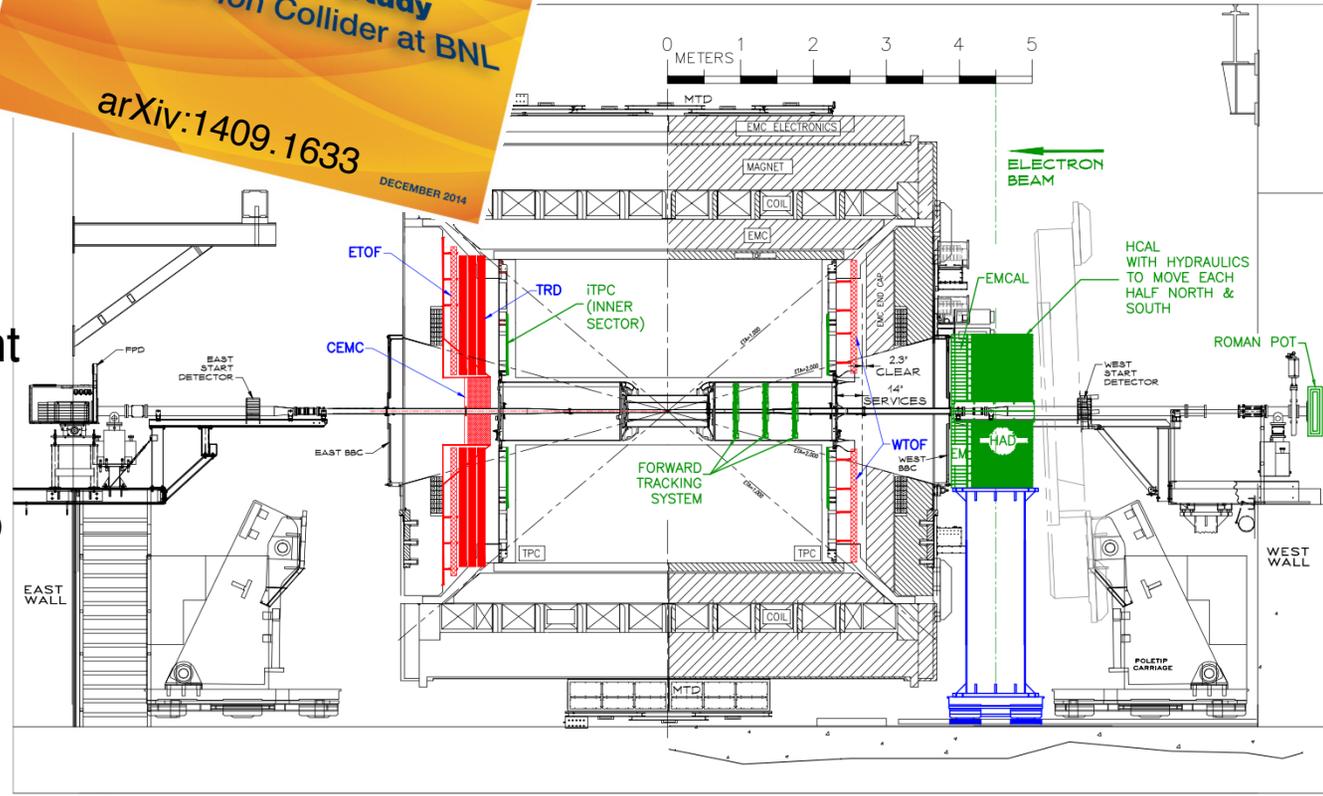


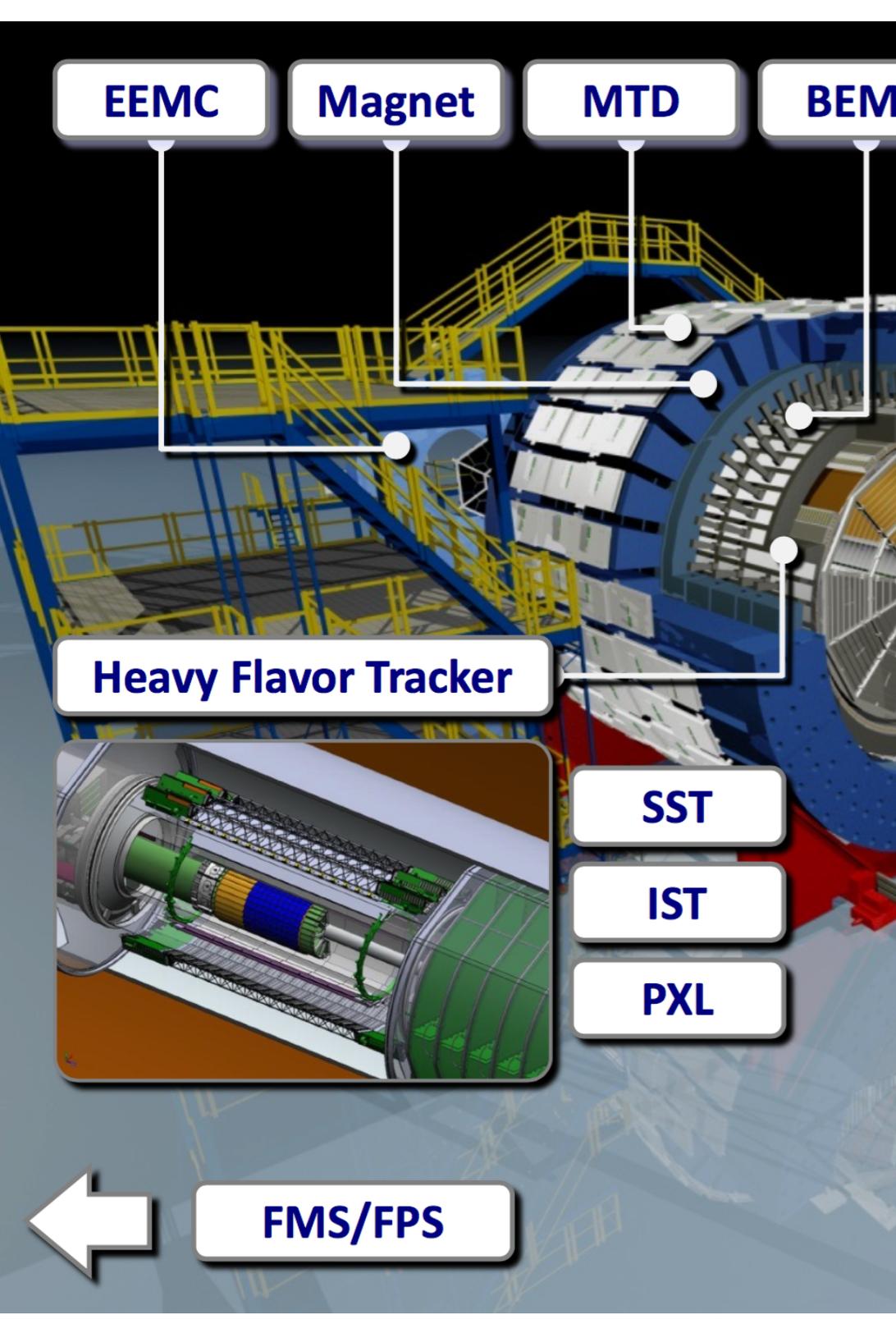
“eSTAR” concept was originally conceived for meRHIC energies;

A suitable forward upgrade on the electron-going side is essential to initial measurements at eRHIC

Initial inclusive and semi-inclusive measurement capabilities demonstrated in simulations for the “instrument at IP6”

Starting collaboration effort to transition towards an eRHIC *optimized* design (replace magnet, mid-rapidity instrument).



A 3D cutaway diagram of the STAR detector at RHIC. The detector is cylindrical and composed of several concentric layers. Labels in white boxes with blue text point to various components: EEMC (Endcap Electromagnetic Calorimeter) at the top left, Magnet (the central solenoid) in the middle, MTD (Mid-Target Detector) on the right side, BEMC (Beam Energy Monitor Calorimeter) at the bottom right, TPC (Time Projection Chamber) as the large central volume, TOF (Time-of-Flight) at the bottom, and BBC (Beam Background Calorimeter) at the bottom left. A callout box labeled 'Heavy Flavor Tracker' shows a detailed view of the inner tracking region with various sub-detectors: SST (Silicon Strip Tracker), IST (Inner Silicon Tracker), and PXL (Pixelated LAr Tracker). At the very bottom left, a white arrow points left towards a box labeled 'FMS/FPS' (Forward Multiplicity Spectrometer / Forward Photon Spectrometer).

EEMC

Magnet

MTD

BEMC

TPC

TOF

BBC

Heavy Flavor Tracker

SST

IST

PXL

FMS/FPS

STAR is a very versatile instrument,
Very successful running periods,
Well on track towards achieving the
heavy-flavor goals with HFT and MTD
(runs 14-16),

Proposal to upgrade the inner sectors
of the TPC, aimed primarily at BES-II;
new EPD and potentially endcap ToF

Gaining qualitatively new capability at
forward rapidities with FPS, Roman
Pots - with rapidly evolving physics-
driven plans and prospects: tail-
catcher, FCS+FTS.

Future forward challenges in the
transition to eRHIC on the electron-
going side, transition to an eRHIC
optimized design.

Thank you!